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Best Management Practices for Nitrogen Use in SOUTHWESTERN AND WEST-CENTRAL MINNESOTA

BEST MANAGEMENT PRACTICES FOR NITROGEN APPLICATION

Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota

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Introduction

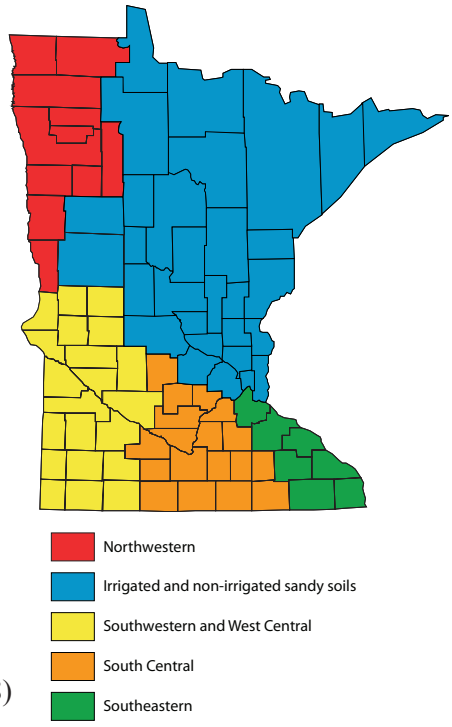
Nitrogen (N) is an essential plant nutrient that is a major input for profitable crop production in Minnesota. In addition, large quantities of nitrogen are part of the crop production ecosystem, including soil organic matter. Biological processes that convert nitrogen to its usable and mobile form (NO_3) occur continuously in the soil system. (For detail, see ***Understanding Nitrogen in Soils* - AG-FO-3770**). This nutrient has a substantial effect on the agricultural economy of the state. While the economic benefits are positive, nitrogen in the form of nitrate – nitrogen (NO_3-N) can be lost from the soil system. This loss is a major focus of public concern when the quality of both ground and surface waters is considered. There are appropriate management practices that can be used to minimize loss of NO_3- N to waters. This publication provides a description of the best management practices (BMP's) that optimize N fertilizer input efficiency while at the same time reducing the potential for loss of NO_3-N. The BMP's that are identified have evolved from the results of considerable research.

The research-based Best Management Practices (BMP's) described in this publication are economically and environmentally sound. It is strongly suggested that they be used voluntarily.

What Are the Best Management Practices (BMP's)?

BMP's for nitrogen use are broadly defined as "economically sound, voluntary practices that, when used, are capable of minimizing nitrogen contamination of both ground and surface waters." The recommended BMP's are based on research conducted at both the University of Minnesota and other land-grant universities. They are practical suggestions. The BMP's described in this publication were developed for the unique soil and climatic production environments of southwestern and west-central Minnesota. (see map)

Nitrogen BMP's for Southwestern and West-Central Minnesota



This region of the state is characterized by soils that have a medium to fine texture which were formed from loess, glacial till, or lacustrine deposits. The large majority of the soils have moderate to poor internal drainage and tile has been installed to improve production. Growers who manage coarse textured (sandy) soils are referred to publication **08556** (revised, 2008) entitled "***Best Management Practices for Nitrogen Use on Coarse Textured Soils***".

Corn, soybean, wheat and sugarbeet crops are dominant in the region. Therefore, the BMP's are focused on the production systems that include these crops. BMP's for wheat production are listed in the BMP publication for northwestern Minnesota, (**AG-FO-6130**, revised, 2008).

The BMP's for the region can be summarized as follows:

1) Recommended For Corn Production

- Select the appropriate N fertilizer rate using U of M guidelines ("***Fertilizing Corn in Minnesota***", **FO-3790-C**, 2006) which are based on current fertilizer and corn prices, soil productivity, and economic risk.
- Total N rate should include any N applied in a starter, weed and feed program, and contributions from phosphorus fertilizers such as MAP and DAP.

- Use a soil nitrate test when appropriate, by collecting soil samples to a depth of 24 inches in 0 to 6 and 6 to 24 inch increments. Collect fall soil samples after soil temperature at 6 inches stabilizes below 50°F.
- For urea (46-0-0) or anhydrous ammonia (82-0-0) applied in the fall, delay application until after soil temperature at 6 inches stabilizes below 50°F.
- Incorporate fall applied urea (46-0-0) as well as spring applied urea (46-0-0) and UAN (28-0-0) within 3 days to a minimum depth of 3 inches.
- Take appropriate credit for previous legume crops and manure used in the rotation.
- Under rain fed (non-irrigated) conditions, apply sidedress N before corn is 12 inches tall (V7 stage).
- When soils have a high leaching potential (sandy texture), a split application is preferred. Use a nitrification inhibitor with early sidedressed N applied to these soils.

2) Acceptable For Corn Production, But With Greater Risk

- Late fall or spring preplant application of ESN.
- Use of the products, Agrotain and N-Serve, with fall applied N.

3) Recommended For Sugarbeet Production

- Use a soil nitrate test by collecting soil samples to a depth of 4 feet after soil temperature at 6 inches stabilizes below 50°F.
- Apply ammonium based fertilizer N in the fall according to U of M guidelines (110 to 130 lb. N per acre). The N rate is a total of NO_3-N measured to a 4 foot soil depth plus fertilizer N.
- Apply fertilizer N in the fall after soil temperatures at the 6 inch depth stabilize below 50°F.
- Take first and second year credits for forage legumes that were part of the rotation.

4) Not Recommended For Corn and Sugarbeet Production

- Fall application of UAN (28-0-0) or any fertilizer containing nitrate-nitrogen.
- Shallow or no incorporation of urea (46-0-0) applied in the fall.
- Fall application of any N fertilizer to coarse textured (sandy) soils.
- Winter application of nitrogen fertilizers including MAP and DAP to frozen soils.

Choosing a Rate of N

Corn

Nitrogen rate guidelines for corn production in Minnesota have changed. Yield goal is no longer the major consideration. Instead, rate guidelines are based on: 1) the productivity characteristics of the production environment, 2) the ratio of the cost of a pound of N divided by the value of a bushel of corn, and 3) the producer's attitude toward risk. The guidelines are the end product of numerous trials conducted by University of Minnesota faculty throughout Minnesota. The new guidelines agree with the concept for the approach to fertilizer N applications that will be used throughout the Corn Belt. A more detailed description of these guidelines is provided in the publication, "***Concepts and Rationale for Regional Rate Guidelines for Corn***," **Bulletin PM2015**, **Iowa State University, Ames, Iowa**.

The guidelines for highly productive environments are provided in Table 1.

Table 1. Guidelines for use of nitrogen fertilizer for corn grown on soils considered to be highly productive.

N Price/ Crop Value Ratio	Corn/Corn		Corn/Soybeans	
	MRTN*	Acceptable range	MRTN*	Acceptable range
	- - - - - - N to apply (lb. per acre)[1] - - - - - -			
0.05	155	130 to 180	120	100 to 140
0.10	140	120 to 165	110	90 to 125
0.15	130	110 to 150	100	80 to 115
0.20	120	100 to 140	85	70 to 100

* MRTN = maximum return to nitrogen

[1] N rates are to be reduced by 20 lb. per acre on soils considered to have a medium yield potential due to yield-limiting factors.

It may be difficult to distinguish soils that are considered to be highly productive from those that have a medium productivity potential. In general, optimum yields on soils with a medium productivity potential are usually lower because of such factors as poor drainage, limited water holding capacity in the root zone, severe compaction, and other restrictions to root and/or crop growth.

Sugarbeet

As with corn, the fertilizer N guidelines are not adjusted for yield goal (expected yield). Extensive research with sugarbeet producers in southern Minnesota has led to the conclusion that a supply of 110 to 130 lb. N/acre is adequate for production of high yielding sugarbeets with good quality. This N total is the sum of fertilizer N and soil residual NO_3-N measured to a depth of 4 feet in late

fall after soil temperature at the 6 inch depth has stabilized below 50° F.

Using Nitrogen Credits

Use of appropriate nitrogen credits is essential to avoid excessive application of fertilizer nitrogen. In general, suggested rates of fertilizer nitrogen are affected by:

1) carryover or residual nitrate – nitrogen (NO_3-N)
2) nitrogen from a previous legume crop in the rotation
3) manure applications
4) nitrogen from other fertilizer such as the N supplied in the application of 18-46-0

Carryover or Residual Nitrates

Corn

The use of the soil nitrate test is recommended when corn follows a crop other than soybeans in southwestern and west-central Minnesota. For this test, soil samples are collected in the fall to a depth of 24 inches after soil temperatures at a depth of 6 inches have consistently dropped below 50° F. For the fall sampling, increments of 0 to 6 and 6 to 24 inches are suggested. The 0 to 6 inch increment can be analyzed for NO_3-N, pH, phosphorus, potassium and other nutrients of interest. The 6 to 24 inch increment should be analyzed for NO_3-N only. The total amount of NO_3-N found in this test is used for a credit as follows.

NG = (Table 1 value for corn/corn – (0.60) STN_{0-24})

where:

NG = amount of fertilizer N needed, lb. /acre

STN_{0-24} = amount of nitrate – nitrogen (lb./acre) measured by using the soil nitrate test

More details regarding the use of the soil nitrate test are found in **FO-3790-C** ("***Fertilizing Corn in Minnesota***") available from the Minnesota Extension Service.

Sugarbeet

As with corn, soil collected from below 6 inches should be analyzed for NO_3-N. The 0 to 6 inch increment can be analyzed for NO_3-N, phosphorus, potassium, etc. The soil from 6 to 24 and 24 to 48 inches is analyzed for NO_3-N only.

Nitrogen from Previous Legume Crops

Nitrogen can be supplied from legume crops used in the rotation. Nitrogen credits from these crops are listed in Tables 2 and 3 and should be subtracted from the nitrogen guideline for corn following corn in Table 1. The N credit for the soybean crop has been accounted for in Table 1. The N credit from alfalfa and clover for second-year corn is summarized in Table 3.

Table 2. Nitrogen credits for legumes preceding corn in the crop rotation.

Previous Crop	1st year Nitrogen Credit
	---- lb. N per acre ----
Harvested alfalfa	
4 or more plants/ft²	150
2-3 plants/ ft²	100
1 or less plants/ ft²	40
Red clover	75
Edible beans	20
Field peas	20

Table 3. Nitrogen credits for some forage legumes if corn is planted two years after the legume.

Legume Crop	2nd year Nitrogen Credit
	---- lb. N per acre ----
Harvested alfalfa	
4 or more plants/ft²	75
2-3 plants/ ft²	50
1 or less plants/ ft²	0
Red clover	35

Nitrogen in Manure

Nitrogen in livestock manure is just as important as nitrogen applied in commercial fertilizers. Therefore, any available N in manure should be used as a credit when determining the total amount of fertilizer N needed for both corn and sugarbeets. The process of determining the amount of N supplied by manure is described in other publications that are listed on the back of this bulletin. As with N credits from legumes, manure N credits are subtracted from the guideline values in Table 1 for corn following corn.

N from Other Sources

When determining the total amount of fertilizer N needed, N supplied in other fertilizers cannot be ignored. This is true whether pre-emergence or post emergence herbicides are applied using 28-0-0 as a carrier or applying high rates of phosphate fertilizers containing N (11-52-0 or 18-46-0). This N must be taken into consideration when the rate of fertilizer N to apply for both corn and sugarbeets is determined.

N Application Timing

Corn

When timing of the fertilizer N is considered, crop producers in southwestern and west-central Minnesota have several choices. Results from a comprehensive study at the Southwest Research and Outreach Center at Lamberton confirm this flexibility. Beginning in 1994 and continuing through 2000, two N sources (82-0-0, 46-0-0) were applied at three times (fall, spring preplant, summer sidedress) in continuous corn and a corn-soybean rotation. Several rates were applied.

For continuous corn, this study provided data for 7 years. Average yields for these 7 years are summarized in Table 4.

Table 4. Corn yield in a continuous corn production system as affected by time of application of two N fertilizers.

N Source	Time of Application		
	Fall	Spring Preplant	Sidedress
	bu./acre		
82-0-0	165.7	175.0	177.0
46-0-0	164.8	167.9	170.1

There was no significant difference in yield between sources when fall application was used. Application was made after soil temperature cooled to 50°F and the 46-0-0 was incorporated as recommended.

For the spring preplant N application, yield was significantly higher when 82-0-0 was the N source. The lower yield from the use of 46-0-0 might indicate that there was some N loss when this source was used.

The use of 82-0-0 as a sidedress application produced a yield that was significantly higher when compared to the used of urea. Again, there may have been some volatilization loss from the application of 46-0-0.

In individual years, the ranking of sources for each time of application was not consistent. In some years, 82-0-0 was superior to 46-0-0; in other years, the use of 46-0-0 was superior for any application time. Considering the long term, both sources have a near equal effect on yield with no year-to-year consistency.

Continuous corn yields were slightly reduced for both N sources when applied in the fall. This indicates some loss of fall applied N. The data do not provide for an identification of the mechanism for the N loss.

Nitrogen management information for corn following soybeans is available for three years of this study (1995, 1997, 1999). Average yields for those years are summarized in Table 5. The optimum N rate was 120 lb. per acre for this rotation and yields listed are for that rate.

Table 5. Corn yields in a corn-soybean production system as affected by time of application of two N fertilizers.

N Source	Time of Application		
	Fall	Spring Preplant	Sidedress
	bu./acre		
82-0-0	149.3	142.9	145.9
46-0-0	142.3	146.5	147.2

As with continuous corn, the ranking of the two N sources changed from year to year with very little difference among the three times of application. When averaged over time of application, yield was 146.0 bu. per acre when 82-0-0 was used and 145.5 bu. per acre when 46-0-0 was used.

When averaged over N source, yield was 145.8, 144.7, and 146.6 bu. per acre for the fall, spring preplant, and sidedress applications, respectively. Thus, time of application had no significant effect on yield in this crop rotation.

Considering both rotations that might be used in southwestern and west-central Minnesota and the year to year variability in results, there is flexibility in the optimum time of fertilizer application. Nitrogen fertilizer can be applied in the fall, as a spring preplant, or as a sidedress application.

The data summarized in Table 6. also show that the time of fertilizer N application can be flexible. When 46-0-0 was broadcast and incorporated as the N source, the optimum rate for corn following soybeans was 120 lb. per acre. At this optimum rate, there was very little difference in yield when fall and spring preplant applications are compared.

Table 6. Corn yield in west-central Minnesota as affected by time of application. Average of two locations.

N applied	Time of Application	
	fall	spring
lb. per acre	bu./acre	
0	173.9	169.5
30	175.7	182.5
60	189.5	194.8
90	192.4	193.9
120	200.7	198.4
150	197.6	206.6
180	192.8	195.5

For both corn and sugarbeet production, time of fall application should be dictated by soil temperature. The primary object in fall N application is to maintain the maximum amount of N in the ammonium (NH_4^+) throughout the winter and early spring. Ammonium N sources (46-0-0, 82-0-0) should be the fertilizers of choice. Soil temperature at a depth of 6 inches should be consistently at 50°F or less before fall application is considered. Otherwise, significant amounts of ammonium-N may convert to nitrate-N. This nitrate-N could potentially be lost via denitrification or leaching in the following spring.

Decisions about timing should also take the source of fertilizer N into consideration. Fall application of 28-0-0 is not recommended. The nitrate-N component of this material can be easily lost by the process of either leaching or denitrification.

When applied in the fall, urea should **not** be left on the soil surface without incorporation. Incorporation to a depth of at least 3 inches would be a better choice.

The application of anhydrous ammonia at a depth of 4 to 6 inches is an appropriate choice for a fall application. The placement at this depth reduces the potential for loss of nitrate-N due to denitrification in the following spring.

For several years, there has been an active discussion regarding the potential benefits of a urease inhibitor (Agrotain), and a nitrification inhibitor (N-Serve) for production systems where N is applied in the fall. The products have been evaluated and benefits have either not been documented or at best, are inconsistent in southwestern and west-central Minnesota. Use of these products should be put in the category of "acceptable for corn production, but with greater risk". The product, Agrotain may be of benefit in situations where urea is broadcast in early spring in no-till planting situations. However, these evaluations have not taken place in west-central and southwestern Minnesota. ESN is another product that has not been evaluated in this region.

Sugarbeet

Split applications of fertilizer N have not improved sugarbeet yield as well as recoverable sugar when this crop is grown on fine textured soils (Table 7). When comparing all combinations that could be used, none were superior to a single preplant application.

The results from the study summarized in Table 7 as well as other studies lead to the conclusion that split applications of fertilizer N are not recommended for this crop.

Table 7. Sugarbeet yield and sugar produced as affected by frequency of application of fertilizer nitrogen.

Time of N Application				Yield	Recoverable Sugar
preplant	4-leaf	4-leaf + 3 weeks	4-leaf + 6 weeks		
---------- lb. N / acre ----------				ton/acre	lb./acre
0	0	0	0	14.8	4769
20	20	20	20	17.2	5300
40	40	0	0	16.6	5546
40	0	40	0	17.1	5366
40	0	0	40	17.2	5231
0	40	40	0	17.4	5423
0	40	0	40	16.6	5123
0	0	40	40	16.9	5149
80	0	0	0	17.7	5470
			$LSD_{0.05}$	1.5	485

Incorporation of Fertilizer Nitrogen

In southwestern and west-central Minnesota, incorporation of fertilizer N applied for both corn and sugarbeet production is suggested. Since the majority of the soils in the region are calcareous, loss of N due to ammonia volatilization is a concern. This possible volatilization is a concern when urea or fertilizers containing urea remain on the soil surface without incorporation. Therefore, some incorporation of 46-0-0 and 28-0-0 is a recommended management practice. This incorporation can be achieved with some form of light tillage or cultivation if these materials are applied either in the spring or at sidedress time. Rainfall in excess of 0.25 inches is adequate if it falls within 24 hours of fertilizer application. Incorporation of urea to a greater depth is suggested if this material is applied in the fall.

Related Publications

08560 (Revised, 2008) - Best Management Practices for Nitrogen Use in Minnesota

08557 (Revised, 2008) - Best Management Practices for Nitrogen Use in Southeastern Minnesota

08554 (Revised, 2008) - Best Management Practices for Nitrogen Use in South-Central Minnesota

08555 (Revised, 2008) - Best Management Practices for Nitrogen Use in Northwestern Minnesota

08556 (Revised, 2008) - Best Management Practices for Nitrogen Use on Coarse Textured Soils

AG-FO-5880 - Fertilizing Cropland with Dairy Manure

AG-FO-5879 - Fertilizing Cropland with Swine Manure

AG-FO-5881 - Fertilizing Cropland with Poultry Manure

AG-FO-5882 - Fertilizing Cropland with Beef Manure

AG-FO-3790 - Fertilizing Corn in Minnesota

AG-FO-3770 - Understanding Nitrogen in Soils

AG-FO-3774 - Nitrification Inhibitors and Use in Minnesota

AG-FO-2774 - Using the Soil Nitrate Test for Corn in Minnesota

AG-FO-2392 Managing Nitrogen for Corn Production on Irrigated Sandy Soils

AG-FO-0636 - Fertilizer Urea

AG-FO-3073 - Using Anhydrous Ammonia in Minnesota

AG-FO-6074 Fertilizer Management for Corn Planted in Ridge-till or No-till Systems

AG-FO-3553 - Manure Management in Minnesota

BU-07936 - Validating N Rates for Corn

Iowa State Univ. PM 2015 - Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn

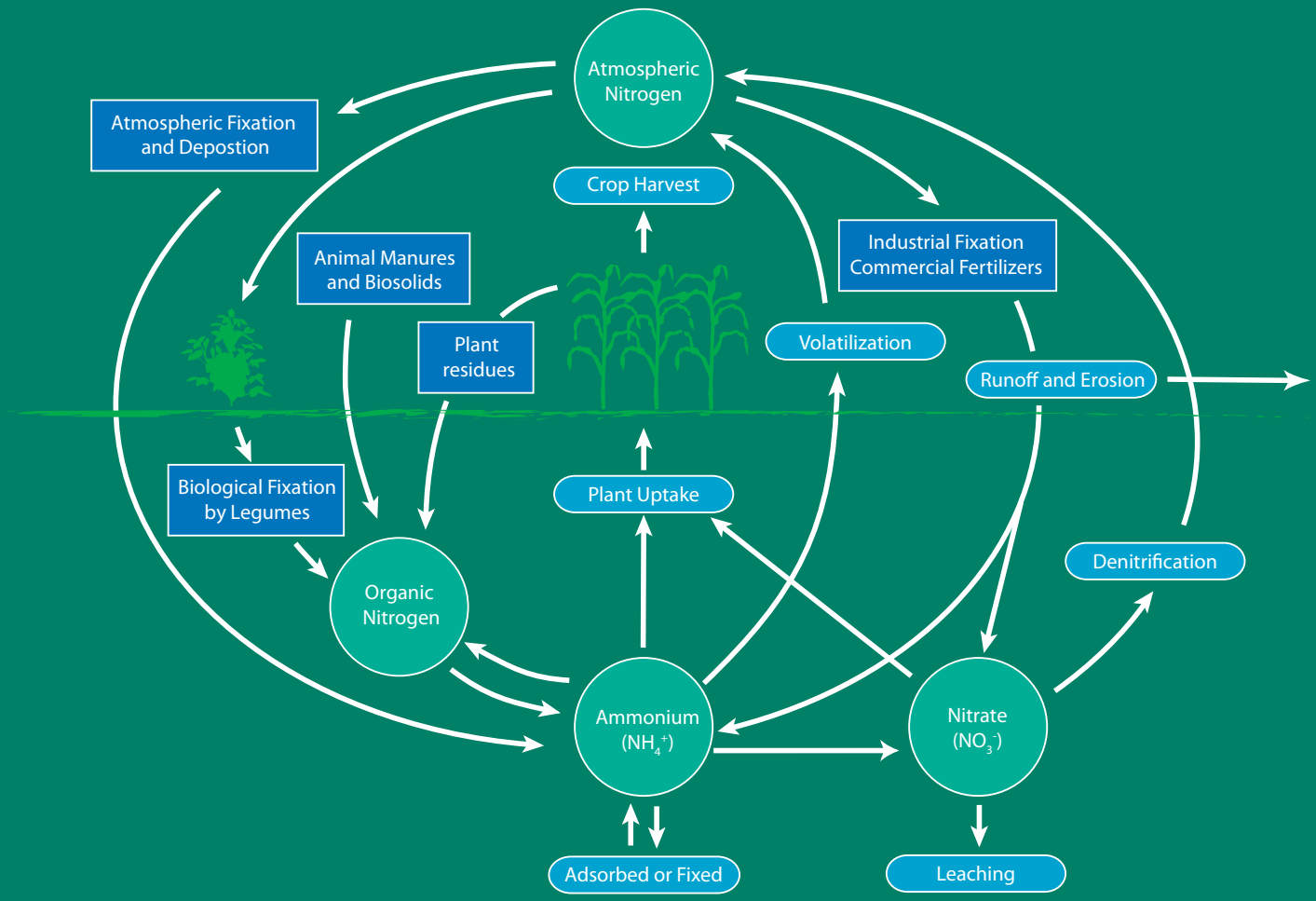
FO-07715-C - Fertilizing Sugar Beet in Minnesota and North Dakota

FO-3772-C (Revised) - Fertilizing Wheat in Minnesota

FO-6572-B - Fertilizer Recommendation for Edible Beans in Minnesota

Summary

Effective and efficient management of nitrogen fertilizers is important for profitable crop production in southwestern and west-central Minnesota. The research based Best Management Practices (BMP's) described in this publication are agronomically, economically, and environmentally sound. They are voluntary. If these practices are followed, agriculture can be more profitable without the threat of regulation.



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PUBLICATION # 08558